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5.7.1 High-Efficiency Motors

Electric motors vary greatly in performance. The selection of energy-efficient motors for HVAC equipment installed in renovation or new construction can result in greatly reduced energy consumption during their operational lifetimes. In converting electrical energy into mechanical energy, motors incur losses in several ways: electrical losses, iron (core) losses, mechanical (friction and windage) losses, and stray losses dependent on design and manufacturing. Energy-efficient motors reduce losses because of their better design, materials, and manufacturing. With proper installation, energy-efficient motors run cooler and thus can have higher service factors and longer bearing and insulation life.

Opportunities

Facility managers should consider installing energy-efficient motors when faced with any motor purchase or repair decision. Replacing a functional motor may be justified solely on the electricity cost savings derived from an energy-efficient replacement. This is especially true if the motor runs continuously, if electricity rates or demand charges are high, if the motor is significantly oversized for the application, or if its nominal efficiency has been reduced by damage or previous rewinds. Priority opportunities are HVAC fan motors and circulation pumps. Efficient motors for other uses should also be considered.

Any time motor replacement is being considered, attention should be paid to the loads served by the motor. Improvements to the overall *system* served by the motor may reduce its load. If this is done at the time of replacement, it may be possible to purchase a smaller, less expensive motor. If it is done independently of motor replacement, the motor may be oversized for the job, so efficiency will be lower.

Technical Information

The tips below relate to motor selection, maintenance, and possible rewinding or replacement.

MOTOR SELECTION

Manufacturers use many terms to describe their most efficient motors, including adjectives such as “high,” “super,” “premium,” and “extra.” These terms create confusion when comparing motors, so purchasers should always consult the nominal efficiency rating and the minimum efficiency rating. Nominal efficiency, an average efficiency of motors of duplicate design, is listed in the manufacturer’s literature and in the *MotorMaster+* software. Even within the group of duplicate designs, there is a some variation in actual efficiencies because of variations in motor materials and manufacturing. Minimum efficiency ratings can be used as the basis for the manufacturer’s guarantee.

To be considered energy-efficient, a motor must meet the performance criteria published by the National Electrical Manufacturers Association (NEMA). Most manufacturers offer lines of motors that significantly exceed the NEMA-defined criteria. Table 12-10 of NEMA (Standard MG-1) delineates efficiency “bins” that form the basis of the “NEMA nominal efficiency” ratings listed on nameplates. The bins provide ranges of efficiencies, such that actual nominal efficiencies are less than or equal to NEMA nominal efficiencies. For example, a motor with an actual nominal efficiency of 92.0 would have a nameplate efficiency listed as 91.7, since the NEMA bracket is 91.7, then 92.4. This standard applies only to Design A and B motors in the horsepower range of 1 to 500. The standard does not cover other sizes and designs, including C, D, vertical, and specialty motors.

Energy-efficient motors run cooler and therefore tend to last longer, and they may require less maintenance. Bearing grease lasts longer at lower temperatures, lengthening the required time between regreasing. Lower temperatures translate to longer-lasting insulation. Generally, motor life doubles for each 18°F (10°C) reduction in operating temperature.

A general guideline for selection of energy-efficient motors is to look for models that (1) have a 1.15 service factor and (2) are designed for operation at 85% of the rated motor load.

Speed control is crucial in some applications. In polyphase induction motors, slip is a measure of how efficiently a motor develops torque. The lower the slip, the higher the efficiency. Less slippage in energy-efficient motors results in speeds about 1% faster than in standard counterparts, which can increase energy use in fans and pumps.

Starting torque for efficient motors may be lower than for standard motors. Facility managers must be careful when applying efficient motors to high-torque applications.

MAINTENANCE

Inspect motors for misalignment or excessive vibration.

Inspect wires and connections on motors and incoming power for damage, corrosion, or looseness.

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Check motor bearings and, on single-phase motors, check for wear on internal switches.

Clean dirt and grease from all motors and especially from the cooling fan and grill on totally enclosed, fan-cooled motors.

Check for electrical power problems that can affect the operation of energy-efficient motors. For example, plant personnel in one manufacturing operation blamed motor failures on the energy-efficient designs of their motors. However, further investigation revealed poor incoming power quality. Investigators suggested addressing the power quality instead of replacing the energy-efficient motors.

REPLACEMENT CONSIDERATIONS

Sizing motors is important. Do not assume that an existing motor is properly sized for its load, especially when replacing motors. Many motors operate most efficiently at 75–85% of full-load rating. Undersizing or oversizing reduces efficiency. For large motors, facility managers may want to seek professional help in determining proper sizes and actual loadings. There are several ways to estimate actual motor loading: the kilowatt technique, the amperage ratio technique, and the less reliable slip technique. All three are supported in the *MotorMaster+* software.

Instead of rewinding motors, consider replacing them with an energy-efficient version, as even high-quality rewinding will result in some loss of efficiency. For larger motors, if motor rewinding offers the lowest life-cycle cost, select a rewind facility with high quality standards to ensure that motor efficiency is not adversely affected. For sizes of 10 hp or less, new motors are generally cheaper than rewinding. It is cost-effective to scrap most standard-efficiency motors under 100 hp when they fail, provided that they have had sufficient run-time and are replaced with energy-efficient models.

Facility managers can easily estimate operating savings of a high-efficiency motor compared with a typical motor (or an existing motor when replacement is being considered). The following formula is used to estimate the annual operating cost of a motor based on the efficiency at rated load, partial load factor (PLF) in percent, annual operating hours, and electricity rate (see calculation example at the bottom of this page):

$/year efficiency = hp x PLF x 0.746 kW/hp x hours/year x $/kWh

Managers can also use the BestPractices Program's *MotorMaster+* software to estimate operating and energy savings. FEMP offers training to facility managers on the use of Motor-Master+ software.

References

MotorMaster+ 3.0 can be downloaded or used online at: mm3.energy.wsu.edu/mmplus/.

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Drivepower Technology Atlas, E Source, Inc., Boulder, CO, 1996; (303) 440-8500; www.esource.com.

Contacts

BestPractices Program, Office of Industrial Technologies, U.S. Department of Energy; (800) 862-2086; www.oit.doe.gov.

Example of calculating energy cost savings from motor replacement: Consider replacing a 20 hp motor that operates 80% loaded for 8,760 hours per year where electricity costs 5.5 cents per kilowatt-hour. Assume efficiencies are 0.88 and 0.92 for standard and energy-efficient motors, respectively. Notice that this does not include savings from reducing electrical power demand.

Standard motor:	20 hp x 0.80 x 0.746 kW/hp x 8,760 hr/yr x $0.055 per kWh / 0.88	=	$6,535 per year
Efficient motor:	20 hp x 0.80 x 0.746 kW/hp x 8,760 hr/yr x $0.055 per kWh / 0.92	=	$6,251 per year
Savings:	$6,535 - $6,251	=	$ 284 per year